A Synthetic Biology Tool Kit for Manned Missions Outside Low Earth Orbit

Completed Technology Project (2011 - 2012)

Project Introduction

Our goal is to make human missions outside low earth orbit safer and better able to handle the unexpected through the use of synthetic biology as an enabling technology. Our strategy is to develop a "synthetic biology kit" that will allow astronauts, following recipes transmitted from Earth, to make new materials on site. NASA can develop biosynthetic solutions, transmit the "recipe" for gene assembly to the astronauts who will use the kit for synthesis.

The purpose of this project is to create a portable, robust infrastructure for conducting synthetic biology off planet. The period of performance focused on the storage of DNA at room temperature. Our assumption is that missions outside low earth orbit (LEO) will include plants to supply food and regenerate waste, and fermentation with engineered microbes to produce materials such as hydrocarbons and plastic monomers. We propose to add flexibility to these tools by including a large set of genes, and the tools to modify and recombine these genes. These new constructs can then be transferred to fermentation organisms or plants to provide the mission with new capabilities and new materials. The kit will include the following functions: DNA storage, PCR amplification (recover DNA from storage), Rolling circle amplification (amplify DNA), Transformation into E. coli and conjugation into other organisms, Mutagenesis, Gene synthesis (small fragments) and Plasmid cloning and pathway assembly. The kit will be based around a few simple manipulations: pipetting, incubation, filtration, centrifugation and bacterial growth. It will include plasmids, enzymes, reagents, microbial strains and ~10 simple pieces of equipment. Our aim is to make the kit self-sustaining in that most of the components can be made using the kit itself (DNA, enzymes, buffers and reagents), re-used (pipettor, filtration apparatus, centrifuge), or replaced using other mission capabilities (plastic pipette tips, parts for pipettors). The total weight of the kit will be between 3 and 5 kg. DNA weighs very little relative to the weight of current DNA synthesis machines, so we intend to carry an inclusive library of genes instead including: 1. Multiple family members for every industrial enzyme 2. Every published recombinant biosynthetic pathway 3. Every human therapeutic protein or antibody 4. Diagnostic antibodies 5. Regulatory pathways and sensors 6. Recombinant DNA vectors for every organism on the mission (plants, microbes, animals, humans) 7. Gene therapy vectors and genes 8. Vaccines Development of the synthetic biology kit will require a sustained effort over several years.

Anticipated Benefits

Any missions that would like to study synthetic biology for long-duration missions, including lunar and to Mars, would be good candidates for this technology.

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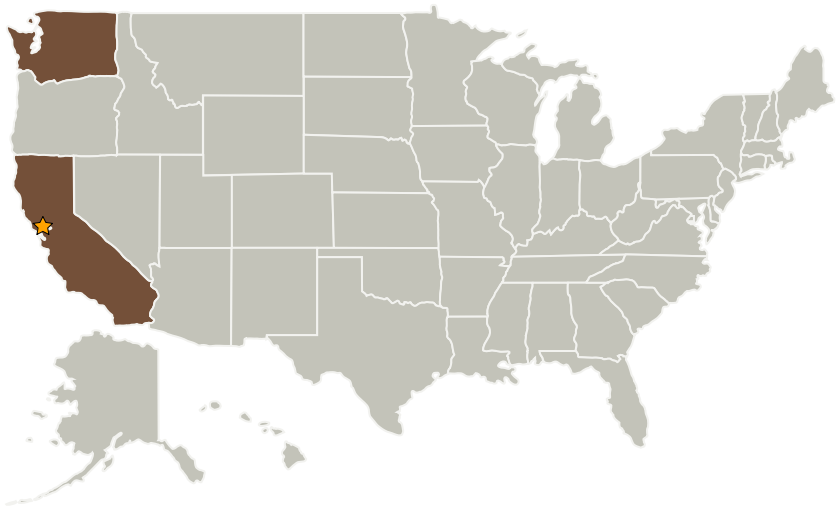
Table of Contents

A Synthetic Biology Tool Kit for Manned Missions Outside Low Earth Orbit

Completed Technology Project (2011 - 2012)

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
★Ames Research Center(ARC)	Lead Organization	NASA Center	Moffett Field, California

Co-Funding Partners	Type	Location
Factory Cells, Inc.	Industry	

Primary U.S. Work Locations	
California	Washington

Stories

1676 Approval #17536
(https://techport.nasa.gov/file/8730)

Organizational Responsibility

Responsible Mission Directorate:
Space Technology Mission Directorate (STMD)

Lead Center / Facility:
Ames Research Center (ARC)

Responsible Program:
Center Innovation Fund: ARC CIF

Project Management

Program Director:
Michael R Lapointe

Program Manager:
Harry Partridge

Principal Investigator:
Lynn J Rothschild

Co-Investigator:
John Mulligan

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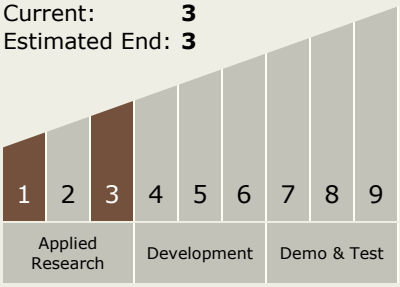
Technology Maturity (TRL)

Start: **1**
Current: **3**
Estimated End: **3**



Technology Areas

Primary:

- TX06 Human Health, Life Support, and Habitation Systems
  - TX06.3 Human Health and Performance
    - TX06.3.7 System Transformative Health and Performance Concepts